JMHT Vol. XVII, (2): 41–48, Agustus 2011
Artikel Ilmiah
ISSN: 2087-0469

Status and Conservation Possibilities of Papua New Guinea's Terrestrial Mammals

David Lopez Cornelio

Department of Forestry, Papua New Guinea University of Technology, Lae-411, Morobe Province, Papua New Guinea

Abstract

The status of Papua New Guinea's terrestrial mammals is revised according to their geographical distribution, life history characteristics, and current conservation plans and legislation. Considering their uniqueness and threatening factors, their appropriate management is critical to achieve sustainable development in the country. Concerning marsupial species no one has been yet domesticated, there is no organized breeding and their natural productivity is generally lower than ruminants. Their conservation status is related to their size as smaller species are usually more prolific, less conspicuous, and less preferred by hunters. Differences on evolutionary ecology between families are discussed, and recommendations are given for the assessment and further conservation of vulnerable species. Conservation programs must go alongside with rural livelihoods improvement through ecotourism, food security, and marketing of non timber forest products.

Keywords: terrestrial mammal, marsupial spesies, conservation status, Papua New Guinea

Correspondence author, email: davlzo26@gmail.com, phone: +675-47-34661, fax: +675-47-34669

Introduction

New Guinea's mammalian fauna consists of 200 relatively small sized monotremes, placentals, and marsupials dispersed in habitats across a broad geographic range. Few species are limited to single islands or island groups, the further they are the higher is the number of endemic species and the lower the number of total species in each island (Dahl 1986). The total number of species of placental mammals, solely represented by rodents and bats, is similar to the total of monotremes and marsupials. Over the past 50,000 years Papua New Guinea (PNG) lost 10 species of large animals (5% of its total mammal fauna) far fewer than any other region (Flannery 1994), it also has one of the largest rates of remaining native forests in Asia; however, the assertion that large areas are still intact is no longer creditable due to high human population growth, poverty risks, weak governance systems, and lack of public resources (Govan 2009). Inextricable links between the land, its resources and the people of PNG, and the widespread practice of hunting alongside the market expansion in a land with a barely known biodiversity and subjected to customary usage, make wildlife conservation of prime importance.

Documentation available on the taxonomy, ecology, distribution, and status of mammalian terrestrial species in PNG is dispersed, outdated, and superficial. In contrast, Australia aims to build biological databases based on next generation sequencing (NGS) that will debunk genes/loci involved in phenotypic variation to assist on animal identification, parentage determination, growth efficiency, population dynamics, and meat yields. Mammal species in Melanesia are widely dispersed or concentrated in certain areas depending on the species, reproductive characteristics, and threats and resilience. Therefore, a general survey will guide future plans to focalize or spread efforts on specific species and areas of PNG.

Methods

Secondary data were compiled and classified in tables describing life cycles, population densities, habitat, and diet to support future breeding plans in semi cautivery. Georeferenced maps (Figure 3) were built with Ilwis 3.6 to describe the spatial distribution of mammalian families in the country, then overlaid on a map of main vegetation types of PNG. The distribution maps are based on literature review, specimens held in the Australia Museum and National Wildlife Collections, limited material that Flannery (1995) examined in North American institutions during 1983 and 1989, and his field chronicles during 1994. The abundance of animals grouped in families per ecological zone (Table 3) was obtained by crossing the rasterized maps in Figure 3 with the ecological map of PNG. Advantages on expanding the actual areas under specific categories of conservation and disadvantages of the sustainability of hunting are discussed.

Results and Discussion

Conservation threats and options Due to a high meat demand local villagers can severely impact prey populations even when they are scarce (Kaplan & Hill 1992), however it is possible to maintain acceptable levels of biodiversity while at the same time allow subsistence hunters to derive value and subsistence from the forests (Alvard 1995). Hunting intensity in some areas of PNG have been reported to be higher than the African average (Nasi *et al*. 2008), its rural population consumes gies may be accepted by locals can be identified by optimal foraging models (Caro 1998) which have also been used to explain the spatial pattern of hunting, how

Table 1 Conservation and alternative optimal foraging theory (OFT) predictions

Type	OFT prediction	Conservation prediction
Interspecific prey choice	Hunters choose prey types that maximize return rate and ignore those that do not	Hunters choose species that are less vulnerable to local extinction
Intraspecific prey choice	Hunters take each sex in proportion to the sex ratio in the prey population, assuming both sexes are in the optimal diet	For polyginous species, hunters choose males in gretaer proportion than their abundance
Intraspecific prey choice	Hunters take adult individuals and ignore immature individuals if they fall out of the body-size range of the optimal diet.	Hunter choose younger and older rather than prime-aged individuals
Path choice	Hunters choose the most profitable patches	Hunter choose patches in proportion to prey abundance
Depletion	Prey may or may not be locally depleted	Prey are not locally depleted

Source: Alvard (1995).

long to stay in a particular resource patch, how far to travel in search of prey, and the role of travel costs in these decisions (FitzGibbon 1998). According to Table 1 hunters are assumed to make decisions that maximize the foraging return rate, measured in terms of resource acquired per unit time spent foraging, therefore selective harvests are the results of how profitably different prey can be killed, rather than how their removal will affect the sustainability of the harvest (Pyke *et al*. 1977).

The impact of deforestation, at a rate of 113,000 ha year^{-1} (WWF 2005) on arboreal marsupials that depend on tree hollows is not well known (Lindenmayera *et al*. 1991). Of the total mammal species 16% are in vulnerable situation, 12% are endangered, 12% are unknown, and 60% are secure (Figure 3). A major goal of a conservation strategy is to preserve the biodiversity in a region (Dahl 1986), for which the strengthening of the national system of natural protected areas, biodiversity assessments (taxonomy, populations, ecology), and sound environmental education and policy are necessary.

In the last 3 decades, the species-by-species conservation concept evolved to ideas of ecosystem conservation and biological community conservation at different levels and spatial scales (Johannes 2002). Natural phenomena and existing policies affect the planning and management of natural areas, such as the climate change by which reserved lands may become unsuitable for various species over the next century, furthermore, the amount of genetic and behavioral plasticity of many species is unknown, and may to some degree be a function of exposure to past climate changes over evolutionary time (CBD 2009).

PNG is not yet party to the World Heritage Convention, Unesco Man, and Biosphere Program or the Convention on Wetlands of International Importance, all of which encourage habitat protection while allowing human use (Collins *et al*. 1991). Customary ownership is widespread over 97% of the country's area, limiting the potential for the establishment of government administered national parks. The IUCN conceptualization of wilderness area does not fit the Meganesian context where land has been actively and extensively managed by aboriginals for over 60,000 years (Flannery 1994). Regional Sanctuaries were endorsed in 4 regions (islands, mainland, highlands, and southern), but their implementation delayed due to lack of finance (Collins *et al*. 1991). PNG also has 15 national parks, 9 provincial parks, 1 recreation park, 2 wildlife provincial parks, 2 nature reserves, 1 historical reserve, 1 hunting reserve, 1 recreational reserve, and 1 wildlife reserve (Kennedy 1992). However, the coverage of protected areas is only 2.7% of the country's land area and 0.07% of its territorial waters (WWF 2005), one of the lowest of any country. The identification of further priority areas for action based on their relative importance is a need. Dahl (1986) proposed a series of simple numerical measures to rank features of conservation interest, risks and feasibility of action that combines ranks for natural conservation status, ecosystem richness, species richness, economic pressure, human threat, natural vulnerability, practicality of conservation action, reliability of data, human impact, and conservation importance.

Counting, fecundity, and productivity The effective management of wildlife depends on the accurate knowledge of population distribution and abundance (Bolen & Robinson 1983) which leads to a healthy and balanced sex and age structure, and a population density consistent with the habitat capability in the long term. Most of the techniques devised to assess the numbers of individuals in free-ranging mammalian populations demand significant time and effort (Wilson & Delahay 2001). Population sizes can be estimated by direct (census) or by indirect (sampling) methods. The last require less effort, reduce the chance of duplicating or missing individuals counting, need not to be completed over a short period of time, and is less disturbed by the census (Caughley 1977), they are also easy to operate, yield unbiased estimators (Barnett 1991) that deviate by less than 10% (Shultz 1966) depending on the sample size and variance (Tanner 1978). However, the time lag between the sign being laid down and being observed make them less directly related to

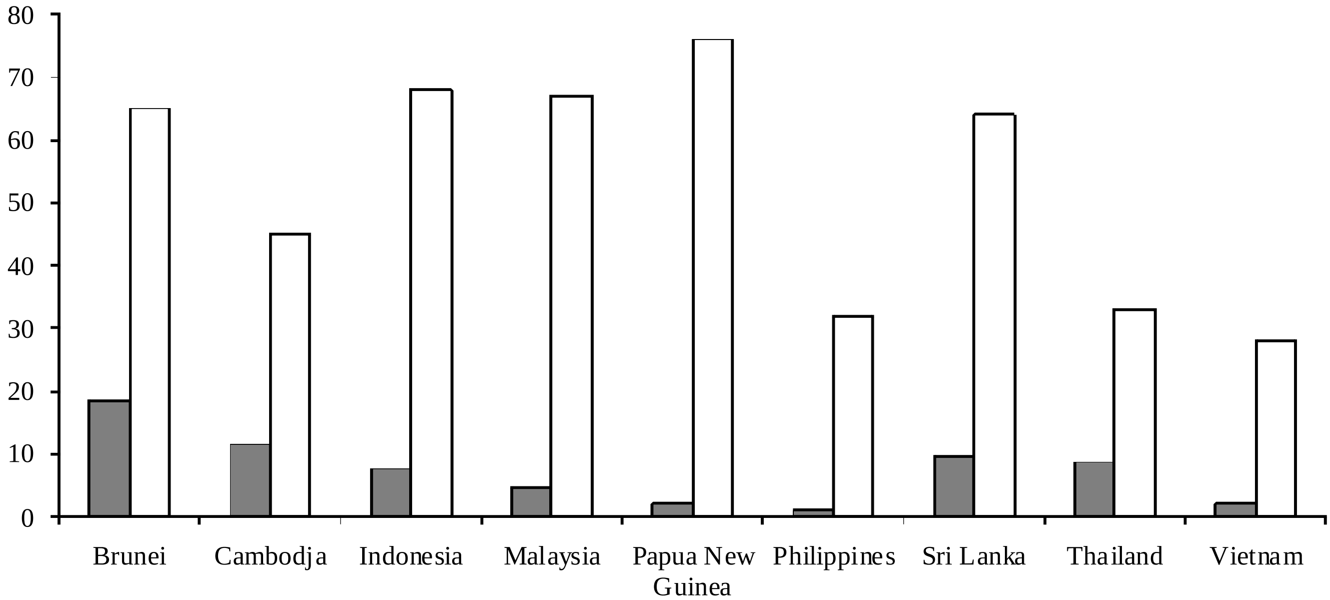

Figure 1 Status of rainforests areas per country in percentage of total area (Collins *et al.* 1991). Conserved (■), remaining (□).

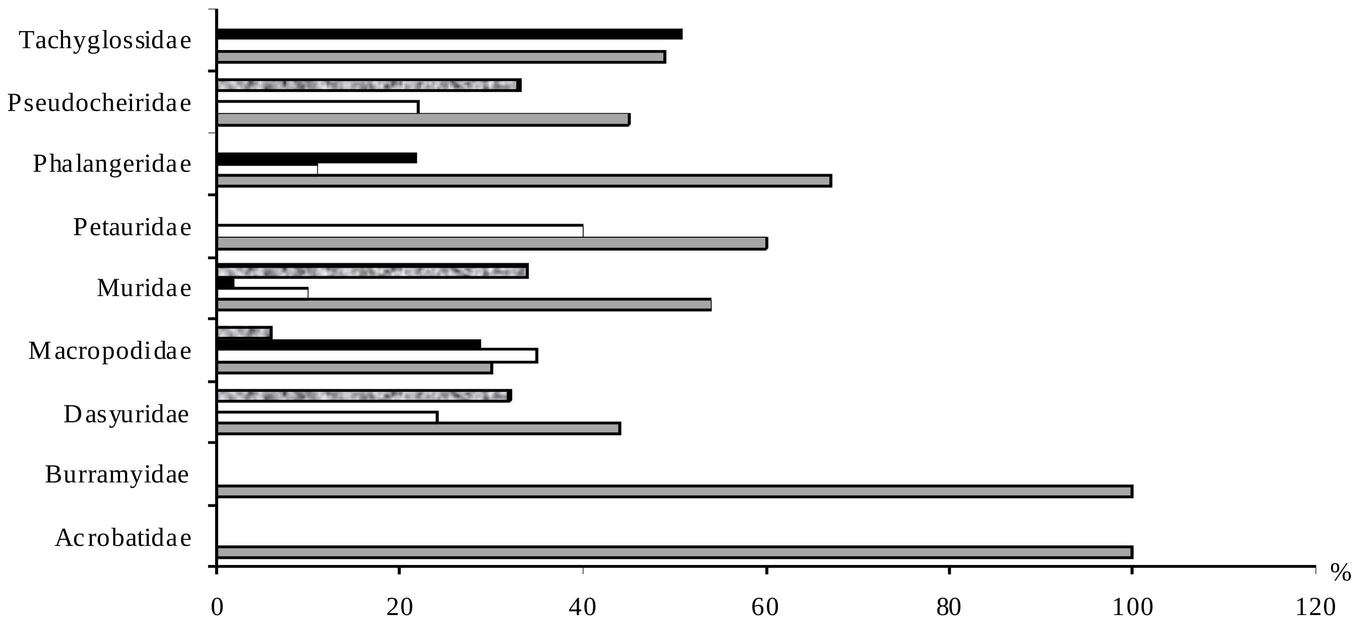

Figure 2 Conservation status per family of terrestrial mammals of Papua New Guinea (Flannery 1995). Unknown (▤), endangered (■), vulnerable (□), secure (▨).

actual density (Caughley 1977).

The probability (β) of seeing or catching an animal is generally lower than 1 (Lancia *et al*. 1994) therefore most census methods do not result in counts of all animals in an area. Natural variations in terrain and vegetation types between areas result in different rates of conspicuousness or catchability. The true population size (N) and count of animals (C) relate as $E(C) = \beta N$, where $E(C)$ denotes the expected value of the count C and β the proportion of animals counted (Cassey & Mcardle 1999). In capture-recapture studies the population is sampled 2 or more times by live-trapping or reobservation without actual capture (Lancia *et al.* 1994). Camera trapping records time series of camera-based encounter rates of the specie as a robust index of animal abundance. It is ideal to identify species in a particular area and monitor their abundance and activity patterns (Yasuda 2004). Lincoln-Petersen, its simplest estimate, assumes that the population is closed, immigration and emigration are

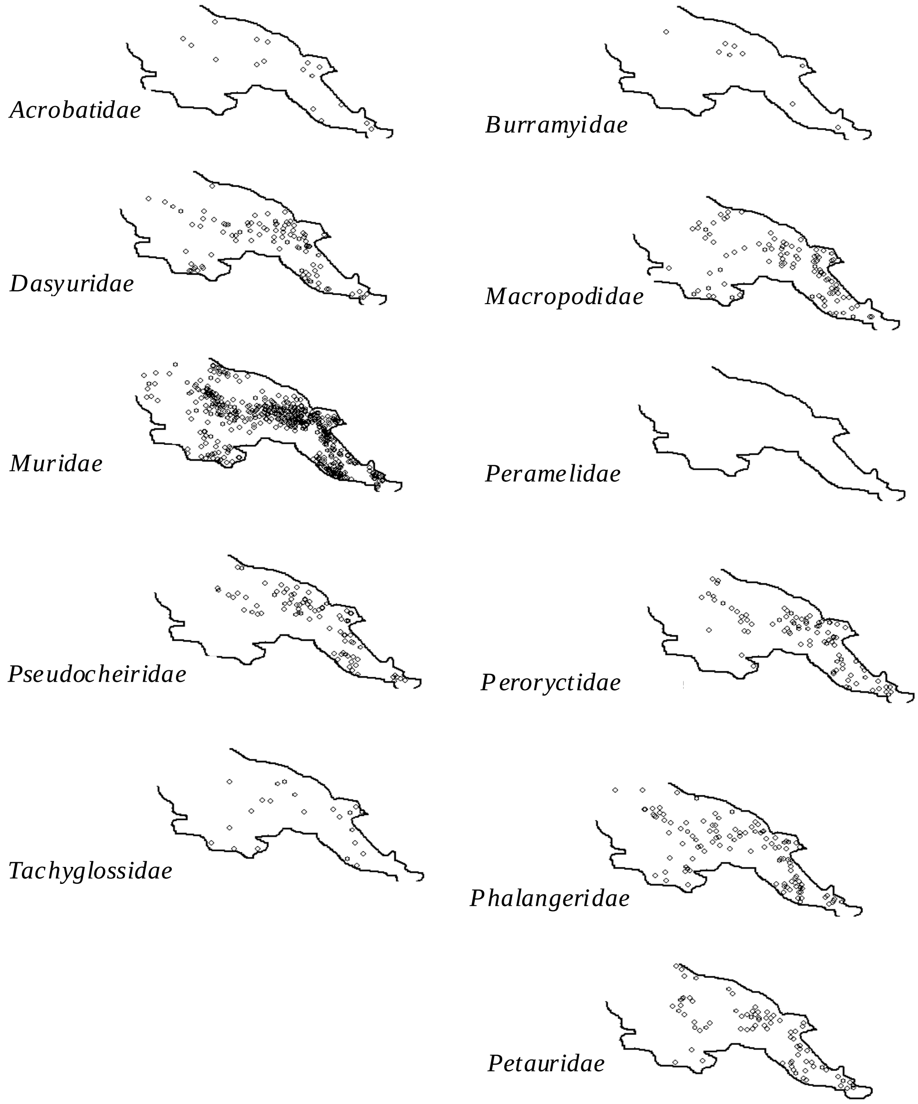

Figure 3 Spatial distribution of mammalian families in Papua New Guinea.

Table 2 Life history of terrestrial mammals of Papua New Guinea grouped into families

Family	Species number	Body mass (g)	Head-body size (male, mm)	Usual litter size	Litters year^{-1}	Age at first parturition (m)
Acrobatidae	1	38–41.4	103–116	2–3	2	6
Burramyidae	1	7–40	90–95	2–4	1–3	5–12
Dasyuridae	8	15–200	80–360	4–12	1–2	6–11
Macropodidae	5	1,800–11,375	435–730	1	1–2	9–25
Muridae	29	10–800	100–418	7–13	10 or more	3
Peramelidae	1	190–1,700	317–447	2–4	2–5	4–6
Peroryctidae	3	150–4,800	275–447	2–4	2–5	4–6
Pseudocheiiridae	2	150–1,000	178–339	1	1–3	unknown
Petauridae	2	115–1,700	240–278	1–2	1–2	8–24
Phalangeridae	2	1,300–3,500	310–540	1	1–2	12–36
Tachyglossidae	2	1,450–13,300	573–656	1	1	unknown

Sources: Horn (1978), Flannery (1995), Lee and Cockburn (1985), Stearns C (1980).

ISSN: 2087-0469

Table 3 Number of collections during years 1983, 1989, and 1993

Family	Montane rainforest	Lowland rainforest	Eucalypt woodland	Forested swampland	Anthropogenous grass	Grassed swampland	Mangroves	Total
Tachyglossidae	6	7	3	1	1	-	-	18
Dasyuridae	27	47	11	3	2	1	-	91
Peroryctidae	49	34	3	2	7	1	1	97
Peramelidae	-	-	3	3	2	-	-	8
Macropodidae	37	35	11	3	3	-	2	91
Phalangeridae	43	45	4	6	9	-	1	108
Acrobatidae	5	7	-	-	-	-	-	12
Burramyidae	3	2	-	-	3	-	-	8
Petauridae	27	29	6	-	7	-	1	70
Pseudocheiridae	32	35	3	-	8	-	-	78
Muridae	159	156	35	15	26	3	4	398
Total	388	397	79	33	68	5	9	979

Source: Flannery (1995).

negligible, the population does not change in size between the mark and recapture sessions, the second sample is by random, marking does not affect the recapture of individuals, and marks are not lost, gained, or overlooked. A sample of n_1 animals is captured, marked, and released. Later, a second sample of n_2 animals are captured, some of which, m_2, are marked. The proportion of marked animals in the second sample should be equivalent to the proportion of marked animals in the total population so that $m_2/n_2 = n_1/N_1$. The type of capture device, traps distribution, trapping interval, handling, identification, marking and type and quantity of bait have to be predetermined (Morrison 2002).

Sampling strip transects are the most common method to estimate population density of arboreal and highly mobile mammals (Timock & Vaughan 2002). The observer moves along a predetermined line and counts all the individuals observed on both sides within a certain distance (Tanner 1978). Quadrat sampling is similar to them in that all animals or their sight within the sampling plot are assumed to be observed in it. Small, randomly or stratified randomly placed plots (square or rectangular of 1 to 100 m^2) are surveyed for signs (burrows, tracks, scat) to obtain an index of animal activity over time (Morrison 2002).

Wildlife in Australia is increasingly held for educational purposes, tourism, as part of captive breeding programs, for research, and as pets. Their expanding husbandry is based on enclosure sizes, captive diet, behavior, and breeding (Jackson 2003). In PNG they constitute an important source of protein in the villages impact of hunting and the influence of the marsupial life-history strategies in the sustainability of hunting are poorly known. Mutualisms research like plant/ pollinator, fruit/frugivore, grass/grazer, and fungus/fungivore interactions need further investigation. Being specialized rather than primitive mammals (Lee & Cockburn 1985), some of them developed extreme reproductive adaptation (Table 2); bandicoots (*Peramelidae* and *Peroryctidae*) show little variation in life history traits, but can be distinguished from other marsupials by their rapid reproductive rates, the *Dasyuridae* exhibit a variety of life history strategies explicable in terms of the effect of body size on reproductive rate and the predictability and seasonal availability of food (Lee & Cockburn 1985). Together with the males of the genera *Antechinus* and *Phascogale*, they die after mating by September each year increasing the survival of the young and females (Flannery 1995). The estimated biomass of mid-sized marsupial mammals (923 kg km^{-2}) in PNG is comparable with densities of placental mammals in other perennial tropical forests. Intrinsic rates of increase range from 0.28 for tree-kangaroos (*Macropodidae*) and 0.29 for cuscus (*Phalangeridae*), up to 5.14 for bandicoots/ echymipera (*Peroryctidae*). Estimated population densities range from 0.4–4.0 animals km^{-2} for *long-beaked echidna* (*Zaglossus sp.*) to 150–340 animals km^{-2} for *ringtails* (*Pseudocheridae*). Extraction rates of game in three studies averaged 23.5 ± 9.9 kg km^{-2} $year^{-1}$, with cuscus and bandicoot species numerically comprising the main game, although the first ones are the most important source of protein (LeDee *et al*. 2010). Rates of extraction versus production in PNG indicate that long-beaked echidna, tree-kangaroos, and cuscus are likely to be hunted unsustainably. In contrast hunting of bandicoots and ringtails was lower than maximum production levels, and the high intrinsic rate of increase of bandicoots means that they can potentially provide a sustainable source of protein, in preference to scarcer and intrinsically slower breeding species. Table 3 shows that murids are the most abundant, followed by cuscuses, bandicoots, and wallabies, and that lowland and montane forests have the highest total numbers. Table 4 resumes species habitat and food preferences useful for census (counting and/or trapping) planning.

Table 4 Habitat and feeding habits of terrestrial mammals of PNG grouped in families

Family	Habitat	Diet/trapping method/bait
Acrobatidae (possums)	Nests in tree hollows/leafy vegetation, active climber, and stale beer odour (*Distoechurus pennatus*)	Eats cicads and leafs
Burramyidae	In secondary forests, subalpine grasslands, and very active (*Carcartetus caudatus*)	Mostly captured from nests in pitpit, insectivorous
Dasyuridae (quolls)	Largely terrestrial (*Antechinus habbema*), largely arboreal (*Antechinus melanurus*), partly arboreal (*Antechinus naso*), makes underground nests, nocturnal (*Antechinus habbema*) , crepuscular (*Antechinus naso*), and diurnal (*Phascolosorex dorsalis*)	Carnivorous, traps baited with sweet potato and oil/meat, larvaes (*Murexia longicaudata*), snaptraps baited with peanut butter and oatmeal, rat meat, larvae (*Murexia rothschildi*), captured by hunters using dogs (*Phascolosorex dorsalis*), and pit-trapped in savannah (*Sminthopsis archeri*)
Macropodidae (tree kangaroos, wallabies)	Live in one male groups, crepuscular or diurnal, distinctive odour (*Dendrolagus dorianus*), nocturnal (*Dendrolagus goodfellowi buergersi*), odourless (*Dendrogalus inustus*), solitary in the wild, 0.25 km^2 homerange (*Dendrolagus matschiei*)	Hunted with dogs and grass burning, captured by grabbing the tail, herbivorous, and carnivorous (*Dendrolagus matschiei*)
Muridae	Inhabit holes in river banks (*Crossomys mancktoni*), secretive, in mangrove swamps (*H. chrysogaster*), in rainforest (*Abeomelomys sevia*), in upper montane forest edge (*Pseudohydromys occidentalis*), and several in the same burrow (*H. shawmayeri*)	Insectivorous, tadpoles and frog spawn (*Crossomys moncktoni*) , fish, crustaceans, mussels (*H. chrysogaster*), grass seeds (*Pseudomys delicatulus*), wild bamboo and palms (*Hyomis goliath*), nuts (*Anisomys imitator*), and pit-pit (*Hyomis dammermani*)
Petauridae (sugar glider)	In most forest types (*Petaurus breviceps*), with gliding membrane, in mossy forests, up to 5 animals share a lair on the ground (*Dactylopsila palpator*), pungent odour, nocturnal, extremely active, emits growling calls (*Dactylopsila trivirgata*), most in tree hollows in groups of up to 7 (*Petaurus breviceps*)	Feed on sap and nectar, beetle larvae (*Dactylopsila palpator*), fruits, pitpit, nectar, and pollen (*Petaurus breviceps*)
Pseudocheiridae (medium sized possums)	Most slow-moving (exception: *Pseudochirops albertisii*), sleeps exposed on branches during day (*P. corinnae*), in tall cane grass (*P. forbesi*), in moss forest, torpid by day and agile by night (*P. mayeri*)	Folivorous, leaves, mosses, ferns, lichens, fungus, and pollen (*P. mayeri*)
Tachyglossidae (echidnas)	Inquisitive, unafraid, and not noisy	Insectivorous

Source: Flannery (1995).

Conclusions

Conservation efforts must still rely on studies done with related species in Australia, and must go alongside the improvement of rural life standards to diminish the reliance on hunting until depletion of the resource. Therefore complementary economic activities to the traditional ones have to be promoted alongside land use planning. Attitude will change when locals perceive economic benefits from living wildlife, besides their intrinsic value to ecosystem structure and function. In the meanwhile, consensual regulations that limit (spatially and/or temporally) traditional hunting of cuscus, tree kangaroos, and echidnas in particular, the expansion of WMSs specially on montane and lowland rainforests, and environmental education programs funded by the state or from abroad, are still necessary. As much as 7 of 9 marsupial families in the country include species with unknown, endangered or vulnerable status. Most small sized species of peroryctides (bandicoots), dasyurids (quolls), murids (rats), acrobatydes, and burramyids (possums) are secured and able to endure controlled harvests in the traditional way; however continuous monitoring of their populations in the

ISSN: 2087-0469

wild through capture-recapture and sampling strip transects are needed to confirm their actual numbers and possible maximum sustainable yields, together with the species life history knowledge, a proper management for each of them can be designed based on a better understanding of their ecology.

References

Alvard M. 1995. Intraspecific prey choice by Amazonian hunters. *Current Anthropology* 36:789–818.

Barnett V. 1991. *Sample Survey Principles and Methods*. London: Edward Arnold.

Bolen EG, Robinson WL. 1983. Wildlife Ecology and Management. Eigth edition. Columbia: Prentice hall.

Caro T. 1998. *Behavioral Ecology and Conservation Biology*. First edition. USA: Oxford University Press.

Cassey P, Mcardle B. 1999. An assessment of distance sampling techniques for estimating animal abundance. *Environmetrics* 10:261–278.

[CBD] Conservation Biological Diversity. 2009. *Connecting Biodiversity and Climate Change Mitigation and Adaptation: Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change*. CBD Series No 41. Quebec: Conservation Biological Diversity.

Caughley G. 1977. *Analysis of Vertebrate Populations*. New York: John Wiley and Sons.

Collins N, Sayer J, Whitmore T. 1991. *The Conservation Atlas of Tropical Forests: Asia and the Pacific*. London: Macmillan Publisher.

Dahl A. 1986. *Review of the Protected Areas System in Oceania*. United Kingdom: IUCN Publication Services.

FitzGibbon C. 1998. The management of subsistence harvesting: Behavioral ecology of hunters and their mammalian prey. In T caro, editor. *Behavioral Ecology and Conservation Biology*. New York: Oxford University Press.

Flannery T. 1994. *The Future Eaters: An Ecological History of the Australasian Lands and People*. Sydney: Reed New Holland.

Flannery T. 1995. *Mammals of New Guinea*. New York: Cornell University Press.

Govan H *et al*. 2009. *Community Conserved Areas: A Review of Status and Needs in Melanesia and Polynesia*. Http://www.sprep.org/att/irc/ecopies/pacific_region/422.pdf [June 2, 2011].

Jackson SM. 2003. *Encyclopedia of Australian Mammals*. Australia: CSIRO Publishing.

Johannes R. 2002. The renaissance of community-based marine resource management in Oceania. *Annual Review of Ecology, Evolution, and Systematics* 33:317–340.

Kaplan H, Hill K. 1992. The evolutionary ecology of food acquisition. In: Smith EA, Winterhalder B, editors. *Evolutionary ecology and Human Behavior*. New York: Aldine de Gruyter.

Kennedy M, editor. 1992. *Australasian Marsupials and Monotremes, An Action Plan for their Conservation*. Http://www.data.iucn.org/dbtw-wpd/edocs/1992-026.pdf [June 2, 2011].

Lancia R, Nichols J, Pollock K. 1994. Estimating the number of animals in wildlife populations. In: T Bookhout, editor. *Research and Management Techniques for Wildlife and Habitats*. Maryland: The Wildlife Society. pp 215–253.

LeDee O, Cuthbert F, Nelson K. 2010. The challenge of threatened and endangered species management in coastal areas. *Coastal Management Journal* 38 (4): 337–353.

Lee A, Cockburn A. 1985. *Evolutionary Ecology of Marsupials*. Cambridge: Cambridge University press.

Lindenmayera D, Cunninghamb R, Tantona M, Nixc H, Smithd A. 1991.The conservation of arboreal marsupials in the montane ash forests of the Central Highlands of Victoria, South-East Australia: III. The habitat requirements of leadbeater's possum Gymnobelideus leadbeateri and models of the diversity and abundance of arboreal marsupials. *Biological Conservation* 56 (3):295–315.

Morrison M. 2002. *Wildlife Restoration Techniques for Habitat Analysis and Animal Monitoring*. Washington DC: Island Press.

Nasi R, Brown D, Wilkie D, Bennett E, Tutin C, van Tol G, Christophersen T. 2008. *Conservation and Use of Wildlife-Based Resources: the Bushmeat Crisis*. Technical Series 33. Bogor: CIFOR.

Pyke G, Pulliam R, Charnov E. 1977. Optimal foraging: A selective review of theory and tests. *The Quarterly Review of Biology* 52(2): 196–250.

Schultz R. 1966. Game simulation and wild land fire. *Journal of Forestry* 64(12):791–800.

Tanner J. 1978. *Guide to the Study of Animal Populations*. Tennessee: University of Tennessee Press.

Timock J, Vaughan Ch. 2002. A census of mammal populations in Punta Leona Private Wildlife Refuge, Costa Rica. *Revista de Biologia Tropical* 50(3/4):1169–1180.

Wilson G, Delahay R. 2001. A review of methods to estimate the abundance of terrestrial carnivores using field signs and observation. *Wildlife Research* 28:151–164.

[WWF] World Wildlife Fund. 2005. New protected areas for PNG. Http://www.wwf.org.uk/news/n_000000 2021.asp [October 26, 2005].

Yasuda M. 2004. Monitoring diversity and abundance of mammals with camera traps: a case study on Mount Tsukuba, central Japan. *Mammal Study* 29: 37–46.